OrcaLay Manual

Version 3.3a

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1 PROGRAM OVERVIEW

1.1 INTRODUCTION

The OrcaLay pipelay software package enables you to optimise the lay procedures for pipelines and umbilicals and ensure that the integrity of the product is not endangered during the lay operation.

The software analyses the behaviour of the system under conditions specified by the pipelay engineer, and reports pipe geometry and loads. The pipelay engineer will review the results and may then revise the system to improve performance, repeating the analysis as required.

When the pipelay engineer judges the system performance to be acceptable, the OrcaLay software package will be used to produce printed tables of key results for assembly into the pipelay manual.

All analysis carried out in OrcaLay is static. For dynamic analysis, facilities are provided for exporting data files to OrcaFlex.

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1.2 WHAT'S NEW

New In Version 3.3a

- Facilities for automating OrcaLay using a simple script language are now available. This batch script language is essentially identical to that used by OrcaFlex.
- The Search for support liftoff feature of earlier versions has been extended and renamed as Reference Offsets. This now allows the complete analysis calculations to search for offsets determined by specified values of top end bend moment, support clearance or pipe lift.

New In Version 3.2c

Bug fixes

- Summary results for Seabed Sheave Initiation were not being output.
- The Anchor Proof Test was previously including the initiation pullhead. We have been advised that this is not realistic and so the model now used for this calculation excludes the pullhead and consists only of wire.

New In Version 3.2b

Statics convergence has been improved for certain cases.

New In Version 3.2a

- Graphical output is now included in the results presentation. This allows you to graph any reported variable against any other reported variable.
- Summary results tables for Initiation and Laydown analyses can now include any top tension value rather than just ones that appeared in the Complete results tables.
- The Acceptance Criteria are now reported on results tables.
- The cases which are reported by Complete Analysis calculations can now be controlled by the Analysis Data.
- Complete Initiation and Complete Laydown analyses can now start with non-zero payout.
- You can now control which colours are used to draw the various objects shown in the 3D View.
- Buttons to reset convergence and segmentation parameters to their default values have been added to the Common Data form.
- The Minimum allowable Tension for an umbilical can be specified. This can be used to prevent the software from searching for unrealistic slack solutions.
- A new Support Positions Wizard facility has been added which allows you to specify the support coordinates as being points following a prescribed path. The path is assumed to be an initial straight line section followed by a circular arc.

- The facility to output an OrcaFlex data file is now available when using the Seabed Sheave Initiation method.
- The bollard pull calculation now accounts for roller reaction forces. The omission of these in previous versions was conservative since the roller reaction forces reduce the bollard pull.

Bug fix

The bollard pull calculation for Seabed Sheave Initiation now accounts for the return wire. In previous versions this was omitted from calculations which led to bollard pull being underestimated.

New in Version 3.1k

The statics convergence has been improved for certain initiation cases.

New in Version 3.1j

- A new Pipe Top End Connection Stiffness data item has been added to the Vessel data.
- The Complete Initiation and Complete Lay results for pipelines now report Bend Moment of the pipe at the top end.
- The Complete Lay results now report the Vessel Offset which is the horizontal distance between the pipe/umbilical top end and the nominal anchor.

New in Version 3.1i

- Statics convergence has been improved.
- Bug fix: The Common Results page was previously mis-labelling some of the reported vessel coordinates. Previously coordinates labelled as being relative to global axes were in fact reported relative to vessel axes. This has now been fixed.

New in Version 3.1h

The statics convergence was improved for cases which do not use rollers.

New in Version 3.1g

The templates feature was broken in version 3.1f. This has now been fixed.

New in Version 3.1f

- There was an error in the implementation of pipe transitions. Older versions of the program were incorrectly using data from the upper pipe when calculating the allowable stress and code check acceptance criteria for the lower pipe.
- Piggyback pipe coating weights were being reported incorrectly on the Common Results sheet of the program's results. The correct values were used in the calculations - the error only affected the reported values.

New in Version 3.1e

- There was an error in the implementation of the API RP 1111 code check. The Combined Load Design check defines the specified minimum burst pressure to be $P_b = 0.45(S + U) \ln(D / D_i)$. However, previous versions of OrcaLay erroneously defined P_b as $0.45(S + U) \ln(D . D_i)$.
- Seabed Sheave Initiation was not working when the pipelay vessel included rollers.

New in Version 3.1c

Sometimes complete analyses would fail and report an error of convergence when in fact the program should have reported that no allowable cases could be found. This has now been fixed.

New in Version 3.1b

- Vessel Origin is set to zero when opening data files saved by version 1 or 2. This ensures that results match those generated by these previous versions.
- Error messages are now echoed in the message window.
- Seabed Sheave Complete Initiation was sometimes failing to find any allowable cases when some did exist. This has now been fixed.

New In Version 3.1a

Minimum tension acceptance criterion for pipes added.

New in Version 3.0j

In version 3.0h and 3.0i the Vessel length was not being written to or read from the data file. This has now been fixed.

New in Version 3.0i

- Pipe lift was not calculated correctly when the lift sensor does not rotate with the ramp. This has now been fixed.
- In version 3.0h the Vessel origin was not being written to or read from the data file. This has now been fixed.
- Spreadsheet sheet names no longer include ":" characters since they interfere with Excel cross-referencing.

New in Version 3.0h

The significant changes from version 2.0 to version 3.0 are:

- A full validation has been carried out on the program. An independent spreadsheet was written which takes OrcaLay data and produces an OrcaFlex data file. The results produced from this OrcaFlex data file were then compared with the OrcaLay results.
- The definition of vessel geometry is much improved.
- Vessel Type data can be imported from an OrcaFlex file and then stored in the OrcaLay data file. This means that when OrcaLay exports OrcaFlex data files they are ready for dynamic analysis in OrcaFlex.
- A template facility has been added similar to that used by word processors. This allows you to prepare template data files and start new projects based on these templates.
- Contact between rollers and the winch wire used in Initiation and Laydown analysis is now modelled.

1.3 INSTALLING THE SOFTWARE

Hardware Requirements

OrcaLay can be installed and run on any PC compatible computer that has:

- Windows 98, ME, NT 4, 2000, XP or Vista.
- At least 32 MB of memory.
- A screen resolution of at least 800 x 600 (small fonts).

Installation

To install OrcaLay:

- If you are using Windows NT 4, 2000 or XP then first log on with Administrator privileges.
- If installing from CD, insert the OrcaLay CD and run the Autorun.exe program on the CD (on many machines this program will run automatically when you insert the CD). Then select 'Install'.
- If you have received OrcaLay by e-mail or from the web you should have the OrcaLay installation program Setup.exe. You will also need licence files (*.lic) for each dongle that you want to use (if you have not received them you might be able to use the licence file(s) from your previous OrcaLay CD). Place the licence files and the file Setup.exe together in a directory on your machine and then run the Setup.exe program.
- You will also need to install the OrcaLay dongle supplied by Orcina when you purchased or leased OrcaLay. See below for details.

For further details, including information on network and silent installation, see the ReadMe file on the OrcaLay CD. If you have any difficulty installing OrcaLay please contact Orcina or your Orcina agent.

Installing the Dongle

OrcaLay is supplied with a dongle, a small hardware device that must be attached to the machine, or else to the network to which the machine is attached.

Note: *The dongle is effectively your licence to run one copy (or more, if the dongle is enabled for more copies) of OrcaLay. It is, in essence, what you have purchased or leased, and it should be treated with appropriate care and security. If you lose your dongle you **cannot** run OrcaLay.*

Warning: *Orcina can normally resupply disks or manuals (a charge being made to cover costs) if they are lost or damaged. But we can only supply a new dongle in the case where the dongle has failed and the old dongle is first returned to us.*

Dongles labelled 'Hxxx' (where xxx is the dongle number) must be plugged into the machine on which OrcaLay is run. Dongles labelled 'Nxxx' can be used in the same way as ‘Hxxx’ dongles, but they can also be used over a computer network, allowing several users to share the program. In the latter case the dongle should be installed by your network administrator; instructions can be found in the Dongle directory of the OrcaLay CD.

Types of Dongle

Dongles are available for two types of connector **-** for connection to the parallel port or to a USB port, the two types have exactly the same facilities but there are some pros and cons for each type:

- The new USB port dongles may not suit if you are using older machines or operating systems. This is because some older machines may not have a USB port. Also, Windows NT4 and early versions of Windows 95 (prior to OSR 2.1) do not support USB devices without modification. Windows 98, ME and 2000, XP all support USB devices (as will future versions of Windows).
- On the other hand USB ports are a more modern and better technology and are taking over from the old parallel port. All recent machines we have seen have USB ports and indeed some portable/laptop computers now have a USB port and no parallel port.
- USB ports are designed to be capable of having multiple devices attached to one port, so you can plug in the USB dongle and other devices (printers, plotters, etc.) and they won't interfere with each other. The parallel port, on the other hand, wasn't originally designed with multiple devices in mind, so dongle suppliers had to use non-standard interfacing methods to try to make the dongle transparent to other devices. This is not always successful and we have seen a few cases where a printer could not be used on the same parallel port as the dongle. This problem will not arise with USB dongles.

Parallel Port Dongles

The computer side of the dongle has a 25-pin **male** connector which plugs into the standard PC parallel port, which has a **female** connector. Please take care not to insert the dongle into a serial port, which is sometimes a 25-pin male connector on the back of the computer; no harm should occur, but the program will not be able to run. If the parallel port is also needed for another device such as a printer, then the dongle should be plugged into the computer and the printer then plugged into the back of the dongle. The dongle is transparent and should not interfere with signals passing through it to other devices.

If you have any difficulties fitting the dongle, please double check that it is fitted to the right port and that it is the correct way round.

Dongle Troubleshooting

Included with OrcaLay we supply a dongle utility and troubleshooting program called OrcaDongle.exe. If OrcaLay cannot find the dongle then you can use this program to help find the cause of the problem. The OrcaDongle program and its help file can be found in the OrcaLay installation directory. They are also in the Dongle directory on the OrcaLay CD, together with other less commonly needed dongle files. OrcaDongle and other dongle software can also be downloaded from the Dongle Support page on our website. If you need further help then please contact Orcina.

1.4 LAY OPERATIONS

OrcaLay offers a choice of pipe and umbilical lay:

Pipe Lay

The analysis is applicable to all forms of pipelay including ‘S’ lay, ‘J’ lay and reel lay. The OrcaLay model starts from a point of fixity on the lay barge (typically a pipe tensioner or clamp). From this point, the pipe passes over a series of supports, then over the stern of the ship and down to the seabed. The number and location of supports is defined by the user.

On some lay barges, pipe tension is not measured directly but is inferred from measurements of the reaction forces on the supports and from the distance of the pipe above a datum level at a specified point, measured by a pipe sensor.

Some lay spreads incorporate a ramp whose angle to the horizontal can be varied. OrcaLay allows the user to declare that any or all of the pipe supports, the pipe sensor and reference datum, tensioner, clamp, etc. are attached to and rotate with the ramp.

Provision is made for constraints which limit the movement of the pipe relative to the barge - e.g. moonpool edges or a roller box at the bottom of the ramp.

Umbilical Lay (over a chute)

Umbilicals are typically laid from a DSV in preference to a specialised pipelay vessel on cost grounds. OrcaLay assumes that the umbilical is laid from a horizontal cable engine on the aft deck of the DSV, passing over a chute at the stern. The analysis allows for friction between the umbilical and the stern chute.

1.5 STAGES OF LAY OPERATION

The lay operation consists of the following stages:

- Initiation - 2 options: **Anchor** or **Sheave.** A wire runs from an initiation head at the end of the pipe or umbilical to a fixed anchor point on the seabed or through a sheave at the seabed and back to a winch on the ship.
- Lay - the pipe or umbilical runs from the ship to an anchor on the seabed. The true anchor position is not modelled since this may be a great distance along the seabed. Instead the pipe is modelled from the ship to a nominal seabed anchor at a position chosen by the program.
- Laydown - the pipe or umbilical free end is lowered to the seabed by means of a cable running from the end cap to the Handling Sheave on the ship.

Abandonment and Recovery (A&R) - if it becomes necessary to abandon the lay operation owing to heavy weather, the pipe or umbilical is cut, the end cap is attached and the free end is lowered to the seabed. From the analysis standpoint, the abandonment operation is identical to the standard laydown operation. Recovery is the reverse of abandonment. The analysis requirements are therefore covered by the Laydown analysis option, but reporting requirements may differ.

1.6 THE MATHEMATICAL MODEL

The software is based on calculation procedures as used in OrcaFlex, a well established commercial offshore systems modelling package developed by Orcina Ltd.

In OrcaLay the model is 2-dimensional in the plane of lay. If specific 3-dimensional analysis is required, a data file can be exported to OrcaFlex which allows fully-general models to be developed.

1.7 COORDINATE SYSTEMS

OrcaLay uses three coordinate systems, all right handed:

- **Global**: used for reporting pipe or umbilical positions in Single Case results tables.
- For the Pipelay option the Global origin is in the water surface in the plane of the Ramp Pivot.
- For the Umbilical Lay option the Global origin is at the top of the chute.
- For both the Pipelay option and the Umbilical Lay option X is horizontal, positive forward and Z is vertical, positive up.
- **Vessel**: used to define locations in the vessel, except for items rotating with the ramp. The origin is the Ramp Pivot, X is horizontal, positive forward and Z is vertical, positive up.
- **Ramp**: used to define the locations of items which rotate with the ramp. x is measured positive up the ramp from the pivot; z is normal to the ramp, positive up when the ramp is horizontal; positive aft when the ramp is vertical.

1.8 DEMONSTRATION VERSION

The demonstration version of OrcaLay is an actual working copy of OrcaLay except that the default data cannot be edited and you cannot save files, print, export or copy to the clipboard.

The demonstration version provides all the other facilities of the full version, so it allows you to explore the full process of pipelay optimisation. For an introduction see the tutorial.

1.9 TUTORIAL

OrcaLay is a specialised analysis tool for the optimisation of offshore pipelay and umbilical cable lay procedures. It has facilities for analysing:

- The main **Lay** procedure.
- **Initiation**, using either a fixed anchor or a seabed sheave pull-in.
- **Laydown** of the second end.
- **Abandonment** and **Recovery**.

OrcaLay has a complete set of default data and option settings **-** these represent Pipe Lay from a reel barge with five pipe supports on the ramp: we use this as our example. In this tutorial, we will run quickly through the data forms, the principal analysis options, and the results, but we will not cover every item in detail. For more detail, see the following sections of this User Manual.

Data

When you run OrcaLay you will see a screen with a group of data items at the top left.

Open the **Common Data** with a double click of the mouse. This is where you choose between pipe and umbilical lay, and between SI and US units. Leave the selection at Pipe and SI. There are three title strings (Project, Client, User Name) for your convenience in identifying the job. These strings will appear at the head of all results sheets.

There are four tabs below: on the **Environment** tab we define the seawater density; on the **Wire** tab we define the properties of the wire used for initiation and laydown. Ignore the two other tabs for now, and click on the Next button.

The **Vessel Data** form has a space for the Vessel Name **-** also used for titling output. There are five tabs below:

General: defines a number of parameters for the lay barge including the ramp angle to be used, maximum top tension, ship bollard pull, etc.

Positions: names and defines the co-ordinates of a number of locations on the barge, and whether or not they rotate with the ramp.

Configuration: then specifies which of the named Positions are allocated to which functions.

> ***Note:*** *You can define Positions which are not used - for example, if you decide to re-allocate a particular function, you don't have to delete the old position which you are no longer using. Similarly, you can allocate more than one function on the Configuration tab to the same Position setting.*

Supports: defines the positions and properties of the pipe supports, using items from the Positions table.

Constraints: defines geometric constraints such as a roller box or moonpool edge, again using items from the Positions table.

Click the Next button to see the **Pipe Data**. The top left part of the form defines the pipe code to be used (API RP 1111 in this example), and a number of associated parameters. The top right part of the form lists the various Pipe Types detailed in the data set. You can define as many as you wish.

The lower part of the form has four tabs defining the pipe details. The **Main** tab defines the basic pipe properties (OD, wall thickness, E, SMYS, etc.). The remaining tabs provide for adding **Coatings and Linings**, a **Piggyback Line**, and one or more **Internal Lines**. In this way, a complex pipe system such as a pipe-in-pipe can easily be assembled.

Now check the **Lay Data** (OK the previous form and double click on Lay Data). We are going to look at continuous lay in a water depth of 120m with a horizontal seabed. (The program allows an unlimited number of cases to be analysed with positive or negative seabed slope.) The analysis can include an in-line current profile, (**Current** tab) **-** either an exponential format or a user-defined stepwise linear profile, and the **Pipe** tab allows for a change of pipe properties (e.g. wall thickness) and/or a local concentrated load. The example case represents lay of a uniform pipe in a head current.

Main Lay Procedure

Now try running the analysis. Close the data window and select Lay in the top menu bar. Click on Complete.

The main screen will show an elevation view of the lay. The program does repeated static analyses - first determining the requisite length of pipe for analysis, then searching for the near and far limits of acceptable performance, and analysing a selection of intermediate cases. We keep you informed of what is happening through the messaging panel below the menu bar.

Results

Results are presented in Excel compatible spreadsheets. You'll see two sheets - a page of Common Results (these echo the input data and derive some associated parameters) and a sheet of results for the water depth and seabed slope we asked for.

The tabulated results show a range of acceptable lay conditions. Of greatest importance are the top and bottom entries in the table, which show the limits of acceptable performance. Note that the program is considering a wide range of possible constraints:

- Tension must not exceed tensioner capacity.
- Horizontal tension component must not exceed ship bollard pull.
- Pipe stresses must not exceed values given in the selected code.
- Local buckling criteria given in the code must not be infringed.
- Pipe must not contact defined objects (e.g. moonpool edges, roller boxes).

Amongst other results, the table identifies the condition at which the pipe lifts off each pipe support - an important criterion for monitoring the lay.

An important feature is the text which tells you which criterion is the limiting one in each case - essential to allow rational modification of the procedure to achieve the desired lay condition.

More Detail

If you need more detail about a specific lay condition, you can find it by running a Single case (choose Single from the Lay menu). This creates an additional spreadsheet containing load and stress information as a function of arc length along the pipe.

Initiation

Now we can try running an initiation analysis. Look first at the **Initiation Data**. For this example we are going to use the **Seabed Anchor** method, though the program also has facilities for a **Seabed Sheave** initiation.

The program analyses a number of snapshots of the procedure. We have chosen to show four snapshots, though in a real case we would usually select many more.

Now close the Initiation Data and select **Initiation** in the top menu bar and click on Complete.

Again you will see the program doing repeated static analyses, paying out pipe from the vessel. For each length of pipe paid out, the program does the same analysis as for the main Lay, finding the acceptable limits, then filling out the table of results. Note that the pipe is drawn in yellow, the initiation head in blue, and the anchor wire in green. You may have wondered how we choose the length of wire to use - a separate command (Calculate wire length) allows you to determine the length of wire which will avoid uplift on the anchor.

Initiation Results

You'll see another group of spreadsheets appear at the end of the initiation analysis, one for each snapshot. Again, the tabulation allows you to choose from the available range of acceptable scenarios.

Too much information! But the program can create a summary table - at the top of the sheet you can select your preference of top tension for this snapshot (you might choose to minimise the pipe stress, or to have the maximum tolerance on tension). Do this for each snapshot, then select Initiation | Summary from the menu bar. You get a summary sheet which is effectively the complete initiation procedure, ready to cut & paste into the vessel's lay instructions.

As for Lay, if you want more detail for a specific Initiation case, a Single Case analysis option is available in the menu.

Laydown

Laydown analysis follows the same principles as Initiation analysis. The properties of the Laydown head have to be defined and the analysis then proceeds in a number of steps as for Initiation. Single Case and Summary table facilities are provided.

Abandonment and Recovery

Abandonment is the same operation as Laydown, but with different properties for the pipe end cap and perhaps in a different water depth from the planned laydown. Recovery is simply abandonment in reverse. Both procedures may be modelled by supplementary Laydown analyses.

Links to OrcaFlex

OrcaFlex is Orcina's general purpose offshore dynamics package. It is fully three-dimensional and has powerful facilities for modelling vessel motions in waves.

Whenever you run a Single Case in OrcaLay, whether for Lay, Initiation or Laydown, you are offered a check box that allows you to choose whether OrcaLay writes out an OrcaFlex data file corresponding to this analysis case. You can open such a file in OrcaFlex and run additional load cases, such as out-of-plane currents or wave dynamics.

OrcaFlex can also allow you to model special situations, using additional lines, winches, and buoyancy. It can model branching lines, or even multiple ship operations.

Development

OrcaLay is under active development, and we expect to add new features in the near future. We are very open to client suggestions!

1.10 ORCINA

Orcina is a creative engineering software and consultancy company staffed by mechanical engineers, naval architects, mathematicians and software engineers with long experience in such demanding environments as the offshore, marine and nuclear industries. As well as developing engineering software, we offer a wide range of analysis and design services with particular strength in dynamics, hydrodynamics, fluid mechanics and mathematical modelling.

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We have agents in many parts of the world. For details please refer to our website: www.orcina.com/ContactOrcina.

1.11 ORCAFLEX

OrcaFlex is a marine dynamics program developed by Orcina for static and dynamic analysis of a wide range of offshore systems, including all types of marine risers (rigid and flexible), global analysis, moorings, installation and towed systems.

OrcaFlex provides fast and accurate analysis of catenary systems such as flexible risers and umbilical cables under wave and current loads and externally imposed motions. OrcaFlex makes extensive use of graphics to assist understanding. The program can be operated in batch mode for routine analysis work and there are also special facilities for post-processing your results including fully integrated fatigue analysis capabilities.

OrcaFlex is a fully 3D non-linear time domain finite element program capable of dealing with arbitrarily large deflections of the flexible from the initial configuration. A lumped mass element is used which greatly simplifies the mathematical formulation and allows quick and efficient development of the program to include additional force terms and constraints on the system in response to new engineering requirements.

In addition to the time domain features, modal analysis can be performed for individual lines and RAOs can be calculated for any results variable using the Spectral Response Analysis feature.

OrcaFlex is also used for applications in the Defence, Oceanography and Renewable energy sectors. OrcaFlex is fully 3D and can handle multi-line systems, floating lines, line dynamics after release, etc. Inputs include ship motions, regular and random waves. Results output includes animated replay plus full graphical and numerical presentation.

For further details of OrcaFlex and our other software, please contact Orcina or your Orcina agent.

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2 USER INTERFACE

2.1 INTRODUCTION

The OrcaLay window has 3 main areas:

- The Data list (top left) shows the data forms. Double click on an item to open the form and view or edit the data.
- The Title area (top right) displays the Project information.
- The Results area (below) shows the currently selected results. As each analysis is performed, OrcaLay accumulates its results as a sequence of spreadsheets. In addition, it displays a 3D View of the system, including a stylised representation of the lay vessel, and a Message page which carries a comprehensive log of calculations performed.

In addition there is a conventional Windows menu bar, a tool bar, and a status bar, which is used to indicate the progress of each analysis through its various stages.

2.2 DATA FORMS

Data are input manually using a series of forms designed for the purpose. The data forms are largely self-explanatory, and realistic default values are provided where possible. It is the responsibility of the User to ensure that any default values used are appropriate.

Once data items have been used in a calculation they cannot be changed until the model is Reset.

Control Buttons

OK

CLICKING the OK button accepts all the changes made while the Edit Form has been displayed and then closes the form.

Cancel

CLICKING the Cancel button (or equivalently pressing Escape) cancels all the changes made while the Edit Form has been displayed and then closes the form.

Next

CLICKING the Next button accepts the current form and then displays the next form in sequence. Holding the SHIFT key down while CLICKING the Next button causes the previous form to be displayed.

Printing, Copying and Exporting Data

The data form can be printed, copied to the clipboard or exported to a file, by using the pop-up menu. The data for the whole model may be printed using the File | Print Data menu item.

2.3 DATA FIELDS

Data items on each Data Form are displayed in Fields, generally with related fields organised into Groups or Tables. You can select a field with the mouse, or use the keyboard to navigate around the form. TAB moves from group to group, and the arrow keys move across the fields in a group.

Where data are complex the form has pages of a tab index that choose between a number of distinct sections of the data.

Where tabular data are shown on the data form, there is usually a separate field that specifies the number of entries in the table, and if necessary scroll bars are shown - use these to navigate through the whole table. Please note that if scroll bars are present, then only part of the data is currently being displayed.

The following types of fields are used:

Text

A general string of text, used for example for titles and comments.

Name

Some objects is given a name, which you can edit. Object names must be unique - you can not have two objects with the same name. The object names are then used as references by other parts of the data.

Numeric

Numbers can be entered in a number of formats such as 3, 3.0, 0.3, .3 or 3.0 E6. It is possible to enter more digits than those shown in the field, but beware that it will not be possible to see them again without editing again and using the arrow keys to examine the rest of field.

For some numeric data items the value '~' is permitted. For example this is sometimes used to mean 'default value'. Details are given in the descriptions of the relevant data items.

Spin Buttons

These are small buttons with up and down arrows, used for incrementing and decrementing the associated field (such as the number of entries in a table). Using the mouse, CLICK on the upper or lower parts of the button to increment or decrement the associated counter.

Multi-choice Buttons

These are used when a number of options are available. Activate the button to step on to the next available option.

Check Boxes

These show a tick, meaning selected, or are blank, meaning not selected. CLICK or press RETURN to change.

Colour Selection

These show as a block of colour. DOUBLE CLICK or press RETURN to open the Colour Selection dialogue box. The desired colour may now be selected.

List Boxes

These show the current selection, such as the name of another object that this object is connected to. DOUBLE CLICK or press RETURN to show a List Box, and then select another item and RETURN to accept the new choice.

2.4 DATA FORM EDITING

The TAB, SHIFT+TAB, HOME, END and ARROW keys and the mouse can be used to navigate around the Edit Form.

Editing mode is entered by DOUBLE CLICKING a cell with the mouse, or by starting to type alphanumeric characters, which are entered into the field as they are typed. The characters that have been typed can be edited by using the arrow keys to move around (now within the field) and the BACKSPACE and DELETE keys.

Editing mode is ended, and the new value takes effect, when you press RETURN or select another field or button on the form. To end editing mode but reject the edit (and so keep the old value) press ESC.

Many numeric fields have limits on the range of values that can be entered, for example an object's mass must always be greater than zero. Warnings are given if invalid values are typed.

Input can also be from the Windows clipboard. CTRL+C copies the selected field or block of fields to the clipboard whilst CTRL+V pastes from the clipboard into the selected field. In this way data can be easily transferred to and from Spreadsheets, Word Processors, etc.

Mouse Actions

CLICK	Select Field
CLICK+DRAG, SHIFT+CLICK	Select a block of fields
DOUBLE CLICK	Start Edit Mode in this field (please also see Data Fields)
RIGHT BUTTON CLICK	Context sensitive pop-up menu for copying, exporting and printing the form and, for some model objects, viewing additional properties

Group Movement

TAB	Next Group
SHIFT+TAB	Previous Group

ALT+...	Move to the group with this letter underlined in its heading

Field Movement

← → ↑ ↓	Go to adjacent row or column
HOME	Go to leftmost column
END	Go to rightmost column
PAGE UP	Go to top row
PAGE DOWN	Go to bottom row

Table Editing

INS, DEL	Insert or delete a row of a table

Start Editing

0..9, A..Z	Edit (replace)

During Editing

← →, HOME,END	Move within field

End Editing

ESC	Cancel edit
↑ ↓	Accept edit and move to previous/next row
RETURN	Accept edit

Copy / Paste

CTRL+C	Copy selected field/block to clipboard
CTRL+V	Paste from clipboard into selected field
CTRL+D	Fill selection from top (ie. copy down)
CTRL+R	Fill selection from left (ie. copy right)
CTRL+U CTRL+SHIFT+D	Fill selection from bottom (ie. copy up)
CTRL+L CTRL+SHIFT+R	Fill selection from right (ie. copy left)
INSERT	Insert new row in table
DELETE	Delete selected row of table

2.5 3D VIEW

The 3D View is a window showing an isometric projection of the three-dimensional model, and it may be rotated, zoomed and panned to allow any aspect of the system to be viewed. The view is controlled by a number of View Parameters while a scale bar in the view indicates the current View Size.

The 3D View can be printed or exported to a file, or cut or pasted to the Windows clipboard, using the pop-up menu (click the secondary mouse key).

View Parameters

The view shown in a 3D view window is determined by the following parameters, which can be adjusted using the view control buttons at the top left corner of the view window, or the **Edit View Parameters** item on the View menu:

View Centre

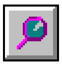
Defines the 3D global coordinates of the point that is shown at the centre of the window.

View Size

The diameter of the view area. It equals the distance represented by the smaller of the 2 sides of the view window. This parameter must be greater than zero.

Interactive View Control

You can also adjust the view in a 3D view window using the view control buttons, in the top left corner of the view:

Button	Action	Equivalent Menu Item
	Zoom In	View | Zoom In
	Edit View Parameters	View | Edit View Parameters

CLICKING the Zoom In button while holding the SHIFT key down causes a Zoom Out action.

Finally, 3D views can also be controlled using various hotkeys - this are listed on the View menu.

Zooming Views

You can zoom in on a particular region of interest in a 3D view by defining a rectangle around it on screen using the mouse. To do this, hold the ALT key down, place the mouse in one corner of the desired rectangle and press down the left mouse button while dragging the mouse to the opposite corner. When you release, the region selected will be expanded to fill the window.

To zoom out, repeat the operation holding down the SHIFT and ALT keys - the region shown in the window will shrink to fit into the rectangle drawn.

You can also zoom in and out by a fixed amount, keeping the same view centre, by using ALT+CLICK and SHIFT+ALT+CLICK.

2.6 RESULTS

Results Tables

All data and associated results are output as worksheets in the Results Spreadsheet. The spreadsheet can be exported in Excel-compatible form for printing or further processing.

Printing, Copying and Exporting Spreadsheets

To print the spreadsheet right click and select Print. However, for control over how the spreadsheet is printed we would recommend saving to file (as described below) and then printing from Excel.

You can also easily transfer the results to other applications by either:

- Copy and paste via the Windows clipboard. Select the block to be transferred and press CTRL+C or select Copy from the Edit menu.
- Saving to file. Right click the mouse and choose Export or select Export Results from the File menu.

Results Graphs

In addition to the tabular results OrcaLay can produce graphs of all results reported in the tables. Free selection of variables for x and y axes is allowed.

2.7 FILES AND TEMPLATES

Data files

OrcaLay data files have filenames with extension ".oly". These contain all the data for Initiation, Lay and Laydown as entered on the various data forms.

Templates

Templates give quick access to pre-prepared data files stored in a templates directory. They are intended to be used to store data which does not change between different projects.

> ***Note:*** *Unlike Microsoft Office a template is simply a normal OrcaLay data file.*

For example, suppose that you always use OrcaLay with the same lay vessel. You can set up a data file which contains all the appropriate vessel data and use this as a template whenever you start a new project.

Template directory

OrcaLay looks for templates in the template directory. This is defined in the following way:

1. OrcaLay starts looking for the template directory in the OrcaLay program directory. This is the directory where the OrcaLay .exe file is installed. By default this is C:\Program Files\Orcina\OrcaLay.
2. If this directory contains a sub-directory called "Templates" then this is the template directory.
3. If this directory contains a shortcut called "Templates" then the template directory is the directory which the shortcut points to.
4. If no template directory is found, then the search is repeated in the parent directory. The search terminates when the top level directory is reached.

For example, assume that the OrcaLay program directory is the default of C:\Program Files\Orcina\OrcaLay. If a directory called "C:\Program Files\Orcina\OrcaLay\Templates" exists then it would be the template directory. Alternatively, suppose that there was a shortcut "C:\Program Files\Orcina\Templates" which pointed to a shared network directory then this network directory would be the template directory.

Creating a template

To create a template you simply save or copy a data file to the template directory.

Using a template

Once you have created a template directory and some templates you can use one of these templates from the File | New menu item. This has a sub-menu containing **Default Model** and the names of each available template. Selecting Default Model sets the data to the standard OrcaLay default values. Selecting a template sets the data to template's data - this is equivalent to opening the template data file.

> ***Note:*** *If no template directory is found, or if the template directory is empty, then the template sub-menu does not appear. In this case File | New sets the data to the standard OrcaLay default values.*

2.8 COMPARING DATA

The Compare Data menu item allows you to find differences between 2 data files. The comparison is performed in the following stages:

- Specify the 2 files which you wish to compare.
- Click the Compare button.
- OrcaLay then saves the data from each file as text files in your system's temporary directory.
- Finally, OrcaLay runs the user specified Compare program to compare the 2 text files.

Configuration

OrcaLay needs a user specified Compare program to perform the comparison of the 2 text files. You will need to specify a program to perform the comparison and the command line parameters for this program.

Compare Program

This is the Compare program's executable filename. This can be either the full path, or just the filename if the executable file resides in a directory which is on your system path.

Command Line Parameters

This defines the command line parameters that are passed to the Compare program. OrcaLay replaces the special strings %1 and %2 with the filenames of the temporary text files. For most compare programs the default setting of "%1 %2" will be sufficient. Otherwise you will need to consult the documentation of your compare program.

2.9 STARTING CALCULATIONS

OrcaLay Calculations

Calculations are actioned by selecting the appropriate item from the Calculation menu.

2.10 MENUS

OrcaLay has the following menus:

- The File menu has the file opening and saving commands, plus commands for printing or exporting data or results.
- The Edit menu has clipboard facilities.
- The Data menu allows you to open the various data forms.
- The View menu provides view control.
- The Calculation menu has commands to perform calculations.
- The Tools menu allows you to adjust preferences.
- The Help menu leads to the various help documentation that is available.

2.10.1 File Menu

New

Either resets all data to default values or opens data from a template.

Open

Opens a previously saved data file.

Save, Save As

Saves a data file.

Compare Data

Compares the data from 2 data files. See Comparing Data for details.

Print Data

Prints the data to the currently selected printer.

Export Results

Save the results as an Excel spreadsheet.

Selected Printer

Allows you to change the selected printer.

Printer Setup

Calls up the **Printer Setup** dialogue. This standard Windows dialogue is used to select which printer to use, and allows you to control the way that it is used - the details vary from printer to printer, and depend on the printer manufacturer's device driver currently installed. Please refer to the manuals for your printer as well as the Microsoft documentation.

Recently used files

List of the most recently used files. Selecting an item on the list causes the file to be loaded.

Exit

Closes OrcaLay.

2.10.2 Edit Menu

Cut

Copies the current selection to the clipboard and then deletes it.

Copy

Copies the current selection to the clipboard.

Paste

Pastes the current contents of the clipboard.

Delete

Deletes the current selection.

Select All

Selects all the text in the message window or all the cells in the results spreadsheet.

2.10.3 Data Menu

Common

Shows the Common data form.

Vessel

Shows the Vessel data form.

Pipe

Shows the Pipe data form.

Umbilical

Shows the Umbilical data form.

Initiation

Shows the Initiation data form.

Lay

Shows the Lay data form.

Laydown

Shows the Laydown data form.

2.10.4 View Menu

Edit View Parameters

Adjust the View Parameters for the 3D View. You can adjust the view centre position and view size.

Zoom In / Zoom Out

Click the zoom button to zoom in (decrease view size) or SHIFT+CLICK it to zoom out (increase view size).

2.10.5 Calculation Menu

Initiation Single

Starts the Initiation Single Case Analysis.

Initiation Complete

Starts the Initiation Complete Analysis.

Calculate Wire Length

Start the automatic Initiation Wire Length Calculation.

Anchor Proof Test

Start the Initiation Anchor Proof Test.

Initiation Summary

Displays the Initiation Results Summary.

Lay Single

Starts the Lay Single Case Analysis.

Lay Complete

Starts the Lay Complete Analysis.

Laydown Single

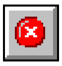
Starts the Laydown Single Case Analysis.

Laydown Complete

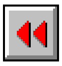
Starts the Laydown Complete Analysis.

Laydown Summary

Displays the Laydown Results Summary.

 **Stop**

Stops the currently active calculation and keeps the results from all previous calculations.

 **Reset**

Stops the currently active calculation and discards the results from all previous calculations. This is needed if you need to modify data items that were used by previous calculations.

Batch Processing

Opens the batch processing form.

2.10.6 Tools Menu

Preferences

Opens the preferences form. At the moment this only allows you to adjust the printer margins.

2.10.7 Help Menu

 **Contents and Index**

Open the Contents / Index / Find in the on-line help.

What's New

Opens the help at the What's New topic.

Tutorial

Opens the help at the Tutorial topic.

Orcina Home Page

Opens the Orcina home page in your system's default web browser.

About

Displays a window giving the program version and details about Orcina Ltd. In addition, the window reports the amount of disk space, memory and Windows resources that are currently free.

3 BATCH PROCESSING

3.1 INTRODUCTION

OrcaLay provides batch processing facilities by means of a simple, text-based script language. Script files can be submitted to the batch form and then processed in unattended mode. The output of the script is a series of Excel workbooks containing results for all the analyses specified in the script.

Scripts are usually used to run a series of variations on a base data file. A script contains a sequence of commands to read a data file, make modifications to it, perform calculations and store the results. The script can also include comments. The syntax for the instructions is described in the next topic.

Script files can be written using any text editor. Alternatively, there are facilities in the OrcaFlex Spreadsheet for automatically generating script files for regular sets of cases.

The batch form is opened by using the Calculation | Batch Processing menu item. This command opens a form that allows you to build a list of scripts to be run. Then, when you run the job, OrcaLay opens and runs each script in turn.

Batch Form User Interface

Close

Dismisses the **Batch** form.

Add File

Files are added to the file list by CLICKING on the **Add** button. The Open File dialogue box is displayed, where you select one or more files to be entered in the **Files To Run** list. To select a group of files, use SHIFT+CLICK and CTRL+CLICK.

Files can also be added by drag and drop. That is if you are browsing your file system then you can highlight files and drag them onto the **Files To Run** list on the batch form.

Remove File

This button removes any files highlighted in the file list.

Run Batch

Start running the listed files. Each file is opened and run in turn, and the file that is currently being run is highlighted in the file list. If any file fails due to errors then that file is abandoned and the batch job continues with the next file. If any errors occur they are reported at the end of the batch job.

Pause Batch

Pauses the currently running batch job.

This can be useful if you temporarily want another process on your machine to have the processor resource that OrcaLay is using. For example suppose that you have OrcaLay and another program both performing processor intensive calculations. The operating system will typically assign 50% of the available processor resource to each process. If you want the other program to finish its calculations quicker then the Pause facility allows you to give 100% of the resource to that other program.

Stop Batch

Terminate the batch job.

Close program when Batch completes

If this is checked then OrcaLay will be closed once the batch of runs is complete. This feature is intended principally for users with networked licences. It allows you to release your claim on an OrcaLay licence as soon as the batch of runs is complete.

3.2 SCRIPT SYNTAX

An OrcaLay batch script is made up of commands, which are obeyed sequentially, and comments, which are ignored. A comment is a line that is either blank or on which the first non-blank characters are "//". A command can be:

1. A directive followed by one or more arguments, optionally separated by white space (one or more spaces or tabs). For example: `LoadData  c:\temp\test.oly` where `LoadData` is the directive and `c:\temp\test.oly` is the argument.
2. An assignment of the form `VariableName=value`, again with optional white space separators. For example: `Length = 55.0.`

Note that:

- Directives, variable names, and model object names are all case independent.
- If your script includes a relative file name then it is taken to be relative to the directory from which the script was loaded.
- File names, arguments, variables or values containing spaces or non-alphanumeric characters must be enclosed in single or double quotes and they must not contain the same quote character as is used to enclose them. For example `'6" pipe'` and `"200' riser"` are valid, but the following are **not** valid:

  `6 inch pipe` - contains spaces, so needs to be enclosed in quotes;

  `6"pipe` - contains a double quote, so needs to be enclosed in single quotes;

  `'6' pipe'` - contains a single quote, so needs to be enclosed in double quotes instead of single.

3.3 SCRIPT COMMANDS

The following batch script commands are currently available. You need to put quotes round file names or other parameters that include spaces or non-alphanumeric characters.

LoadData <FileName>

Opens the OrcaLay file named <FileName>.

SaveData <FileName>

Save the current model to <FileName>.

SaveResults <FileName>

Save results to an Excel workbook called <FileName>.

Reset

Resets the current model. This command is equivalent to the Calculation | Reset menu item.

New

Deletes all objects from the current model and resets data to default values. This command is equivalent to the File | New menu item.

Assignment

Assignment commands take the form

```
VariableName = Value
```

The VariableName on the left hand side must be one of the recognised variable names. The Value on the right hand side must be in the appropriate form for that variable (i.e. numeric or text) and it must be given in the same units as used in the current model.

For example:

```
VesselName = "My Barge"
RampAngle = 30
MaxTopTension = 220
```

If VariableName is the name of a variable that appears in a check box in OrcaLay then the Value should be True or False. For example:

```
SearchForSupportLiftoff = False
```

If VariableName is the name of a variable that appears in a table in OrcaLay, then its row number must be given. The row number is given as an index enclosed by either square or round brackets (don't mix them on the same line), and is always 1-based - i.e. [1] is the first row of the table. Note that this sometimes requires care, since in OrcaLay the table might not be 1-based. For example, when setting the initiation payout data, the command:

```
InitiationPayoutUserStep[2] = 35.0
```

sets the payout in the 2nd row of the table, but in this case the first row of the table is step 0 so this command (slightly confusingly) sets the payout for step 1.

Pipe data requires a little extra work to set. If there are more than one pipe type defined in the model then you must specify which pipe type any assignments refer to, as follows:

```
SelectedPipe = Pipe1
 PipeOD = 180.0
 PipeWallThickness = 12.3
```

If the data contains only a single pipe type then the SelectedPipe assignment can be omitted.

InitiationSingle [<FileName>]

Performs the Single Initiation calculation.

The FileName parameter is optional. If it is included then an OrcaFlex data file is written after the calculation is complete, otherwise no OrcaFlex data file is written.

InitiationComplete

Performs the Complete Initiation calculation.

InitiationSummary

Performs the Initiation Results Summary calculation.

AnchorProofTest

Performs the Anchor Proof Test.

CalcWireLength

Performs the Wire Length calculation.

LaySingle [<FileName>]

Performs the Single Lay calculation.

The FileName parameter is optional. If it is included then an OrcaFlex data file is written after the calculation is complete, otherwise no OrcaFlex data file is written.

LayComplete

Performs the Complete Lay calculation.

LayDownSingle [<FileName>]

Performs the Single Laydown calculation.

The FileName parameter is optional. If it is included then an OrcaFlex data file is written after the calculation is complete, otherwise no OrcaFlex data file is written.

LaydownComplete

Performs the Complete Laydown calculation.

LaydownSummary

Performs the Laydown Results Summary calculation.

3.4 OBTAINING VARIABLE NAMES

Each OrcaLay data item has its own name that is used to specify it in a script file. The names of the data items are based on the corresponding labels used on the data form. To find out the name of a data item, open the appropriate data form, select the data item, and then open (e.g. by right click) the pop-up menu and select the Batch Script Names command (or press F7). This displays the variable name of the selected data item and you can select and copy+paste the name directly into your batch script.

If the data item is in a table (or group) of data items then the Batch Script Names form displays the names of all the data items in the table. The different columns in the table each have their own names; you then need to add an index to specify which row you want.

3.5 AUTOMATING SCRIPT GENERATION

The OrcaFlex Spreadsheet has facilities for automating the generation of a script file for a regular set of cases. Although this was designed primarily for use with OrcaFlex, it works perfectly well with OrcaLay too. If you do not have access to OrcaFlex and would like this spreadsheet then please contact us.

4 DATA

4.1 COMMON DATA

4.1.1 Introduction

The Common Data items are common to all types of analysis.

Project, Client, User name

Free format user defined strings which are used solely for labelling.

Operation

Pipe or **Umbilical**.

Units

These may be **SI** or **US** (imperial). If the units are changed, the program automatically converts all the data in the model into the new units.

4.1.2 Environment

Sea Density

Density of the sea water.

4.1.3 Wire

The same wire data are assumed to apply for Initiation, Laydown and A&R analyses.

Type

Two predefined wires are available, 2" and 2½ ". A "User Defined" option is also available.

Data items for User Defined wire

Outside Diameter

Mass

Axial stiffness (EA)

Handling Winch Capacity

This limits the tension which may be applied to the wire in Laydown and A&R.

Drag Coefficient

This is the normal drag coefficient, relating to the component of flow which is at right angles to the wire.

4.1.4 Analysis

These data control which cases are reported for Complete Analyses.

Target number of cases to analyse

The Complete Analysis calculations are performed in 3 stages:

1. First the program searches for the extreme near and far cases as determined by the Acceptance Criteria.
2. The program searches for any reference offsets specified in the data below.
3. Cases intermediate to those found in stages 1 and 2 are analysed. The **Target number of cases to analyse** data item determines the total number of cases that will be reported.

Include Reference Offsets

The complete analysis first determines the working range and then searches for a number of **reference offset** cases as specified by the data below.

> ***Note:*** *The search to determine reference offsets can be time consuming and so you should only include reference offsets that are of particular interest.*

Search for support liftoff

If this is checked and the vessel has supports defined then Complete Analysis calculations will search for and report cases corresponding to pipe liftoff from each support. Pipe liftoff is deemed to occur when the support reaction equals 0.1kN.

Top end bend moment

If this is checked then Complete Analysis calculations will search for and report cases corresponding to the specified value of top end bend moment.

Support clearance

If this is checked then Complete Analysis calculations will search for and report cases corresponding to the specified value of clearance at the specified support.

Pipe lift

If this is checked then Complete Analysis calculations will search for and report cases corresponding to the specified value of pipe lift.

4.1.5 Segmentation

These data define the way in which the OrcaLay model of the pipe is subdivided for analysis purposes. Four levels of segmentation are defined: **Fine**, **Medium**, **Coarse** and **Touchdown**.

These numbers are relative to the nominal line OD. For a pipe this is the upper carrier pipe OD and for an umbilical this is the umbilical OD. This means that for a pipe it ignores coatings and piggyback lines. So, for example, Fine segmentation means segment lengths of (Fine Segmentation Value) * (nominal OD).

This segment length cannot always be achieved exactly so it should be viewed as a **target** segment length. When the segment length cannot be achieved exactly, the nearest possible shorter segment length is chosen.

We apply these segmentation values as follows:

1. For each **section change** (MPL, pullhead, pipe transition) we use fine segmentation for 10*OD either side of the section change. We use medium segmentation for 40*OD either side of the fine segmentation.
2. We use fine segmentation from between the top end and 10*OD beyond the last support (or top end if there are no supports). We use medium segmentation for 40*OD beyond that.
3. We define the **vertical range** to be the vertical distance from the top end and the seabed. We use touchdown segmentation for arclengths beyond the vertical range.
4. 4. All other areas, together with all wire, MPL and pullhead sections use coarse segmentation.

Reset to Default

Click this button to reset the segmentation parameters to their default values.

4.1.6 Convergence

The convergence parameters control the way in which OrcaLay finds the pipe equilibrium shape. The following parameters can be controlled by the user:

Max Iterations

Tolerance

The non-dimensional accuracy to which the calculation is done, before the calculation is treated as having converged. Increasing the tolerance increases the chances of convergence but reduces the accuracy.

Min damping

It will generally be sufficient to leave these parameters at their default values, but if convergence is difficult or fails to occur, then the convergence parameters may be adjusted to assist. If adjustment is needed, then the following sequence is suggested:

1. Increase Min Damping to 2.0 or 5.0, say.
2. If this fails then increase Max Iterations to 5000.

Reset to Default

Click this button to reset the convergence parameters to their default values.

4.1.7 Drawing

Colours

These data determine which colours are used to draw the various objects shown in the 3D View.

Node Thickness

This determines the thickness of the pen used to draw nodes on the pipe or umbilical. To suppress node drawing use a value of 0.

4.2 VESSEL DATA

4.2.1 Introduction

The Vessel Data items are used to define the geometry of the lay vessel.

Vessel Name

A free format user defined string which is used solely for labelling.

4.2.2 General

Vessel Origin

Location of the vessel origin in the Vessel coordinate system. For Lay analyses the water depth is measured at this point. In addition, the Vessel Offset for Sheave Initiation is measured relative to this point.

When OrcaLay writes out a data file for further analysis in OrcaFlex this is the origin of the vessel in the OrcaFlex model. For more details see the OrcaFlex program documentation.

Vessel Length

Nominal vessel length, used to scale Vessel Type data. A value of '~' means use the same value as the Vessel Type. When OrcaLay writes out a data file for further analysis in OrcaFlex this is vessel length in the OrcaFlex model. For more details see the OrcaFlex program documentation.

Import Vessel Type

Allows the user to import Vessel Type information from an existing OrcaFlex file. This includes the OrcaFlex drawing of the vessel which is used in the OrcaLay 3D view.

OrcaLay only uses the drawing data for the Vessel Type. However, the other Vessel Type data (eg. RAOs) is remembered by OrcaLay. If you choose to export an OrcaFlex file then all Vessel Type data is written to the exported OrcaFlex file.

Data Items used in Pipelay option

Ramp Angle

Degrees from horizontal.

> ***Note:*** *Where there is no ramp as such, this angle is used to define the angle at which the top end of the pipe is fixed and should be set accordingly.*
> *For example, if you are modelling an 'S' lay operation with a horizontal firing line then the Ramp Angle should be 0.*

Maximum Top Tension

Determined by the capacity of the pipe tensioner. This value is used for the acceptance criteria in Complete Initiation and Complete Lay analyses.

Bollard Pull

Limits horizontal component of pipe tension. This value is used for the acceptance criteria in Complete analyses.

Height of Ramp Pivot Point Above the Water Line

The ramp is treated as rotating in the plane of the ship about this point.

Data Items used in Umbilical Lay option

Height of Chute Top Above Water Line, Chute Included Angle

The chute is assumed to form a circular arc, horizontal at the top. The angle required is from the top of the chute to the end of the arc. The umbilical is not permitted to wrap beyond this point in Complete analyses - see acceptance criteria.

4.2.3 Positions

This table allows the user to:

- Define an arbitrary number of positions on the ship.
- Assign an appropriate name to each position.
- Determine whether the position rotates with the ramp or not.

The positions given here are used to define the lay spread geometry, but it is not necessary for every entry in the Positions table to be used. For example, the ship may be fitted with two handling winches, only one of which is in use during a specific lay operation. It may be convenient to define the positions of both, then select the one required in the Configuration page.

Positions are defined by x, z coordinates. If a specific position is declared as rotating with the ramp, then the x, z coordinates are interpreted in the Ramp coordinate system; if not, then the coordinates are interpreted in the Vessel coordinate system.

4.2.4 Configuration

These data items define the positions of various points used in the analysis. The coordinates are defined on the Positions page.

Pipe Top End, Pipe Top End z adjustment

The pipe is modelled from this point.

- For Reel lay, it will be the tensioner exit.
- For 'J' lay, it will be the fixed pipe clamp.
- For 'S' lay, it should be a convenient point of fixity near the aft end of the firing line, e.g. the last firing station.

The z coordinate at the Pipe Top End is the height to the lower edge of the pipe and may vary with pipe diameter. The lower edge of the pipe is set at a z value given by

$$z = PTE_z + a.D$$

where PTE_z is the z coordinate of the Pipe Top End position, a is the Pipe Top End z adjustment and D is the pipe OD including coatings (if any).

> ***Note:*** *If the z coordinate at the Pipe Top End* ***does not*** *vary with pipe diameter then Pipe Top End z adjustment should be set to 0.*

Pipe Top End Connection Stiffness

The connection stiffness at the pipe top end. A value of "Infinity" will result in the pipe top end connection being modelled as a rigid connection.

Distance to Upper Pipe Hangoff

Used for analysis of 'J' lay only. After a new stand of pipe has been welded in place, the pipe is supported from a temporary hangoff whilst the clamp is released, the pipe is lowered, and the ship moves forward. This data item defines the distance of the temporary hangoff from the clamp, measured along the pipe.

> ***Note:*** *If you are not analysing 'J' lay then the default value of 0 should be used.*

Handling Sheave

For Laydown analysis the wire is connected at this point.

Pipe Sensor Position

This defines the location of the sensor used to measure pipe lift. Positive values of pipe lift mean that the pipe is above or aft of the datum.

- If the sensor rotates with the ramp then pipe lift is measured normal to the ramp, from the sensor to the pipe underside.
- If the sensor does not rotate with the ramp then pipe lift is measured horizontally, from the sensor to the pipe underside.

Initiation Payout Origin

The reference point from which Pipe Length (i.e. payout) is measured for Initiation.

Laydown Payout Origin

The reference point from which Wire Length (i.e. payout) is measured for Laydown.

Suspended Length Origin

The reference point from which Suspended Length, Horizontal Projection, Vertical Projection, Projection Growth and Distance to Target are measured.

4.2.5 Supports

These data items define the positions and characteristics of the pipe supports, if any. The pipe supports are assumed to take the form of horizontal rollers. The position defines the roller centre and OrcaLay adds in the roller radius. Data items are:

Roller Diameter

Measured at the point of contact with the pipe.

Support Stiffness

This is the total effective stiffness of the support, including the effects of pipe ovalisation.

x, z, Rotates with ramp

The coordinates of the support are defined by x and z. If a support is declared as rotating with the ramp, then these coordinates are interpreted in the Ramp coordinate system; if not, then they are interpreted in the Vessel coordinate system.

Support Positions Wizard

This facility allows you to specify the support coordinates as being points following a prescribed path. The path is assumed to be an initial straight line section followed by a circular arc. The supports are all assumed to rotate with the ramp.

Radius to Pipe Underside, Distance of Straight Section from Pipe Top End

These data determine the geometry of the circular arc and the straight section respectively.

Pipe Reference OD

The diameter of the carrier pipe.

Arclength, Distance along Ramp x-axis, Angle

These data items specify where each support is placed on the circular arc. Note that each data item is related so changing one value will result in the other two values being updated.

Arclength and Distance along Ramp x-axis are measured from the end of the straight section. Likewise an angle of zero corresponds to the end of the straight section.

4.2.6 Constraints

These data items define the positions of objects which constrain the movement of the pipe. Examples might include a roller box, or the edges of a moonpool.

Data items are:

Name

User defined title string.

x, z, Rotates with ramp

The coordinates of the constraint are defined by x and z. If a constraint is declared as rotating with the ramp, then these coordinates are interpreted in the Ramp coordinate system; if not, then they are interpreted in the Vessel coordinate system.

Constraint Sense

For each constraint, specify whether the constraint is Forward or Aft.

- Constraint is to the **Below/Fwd** means that the pipe is not permitted to pass forward of or below the constraint (e.g. the forward edge of the moonpool).
- Constraint is to the **Above/Aft** means the pipe is not permitted to pass aft of or above the constraint (e.g. the aft edge of the moonpool, or the top roller in a roller box).

> ***Note:*** *The constraints are part of the acceptance criteria when performing a complete analysis. For a single analysis, the acceptance criteria do not apply and the distance to each constraint will be reported.*

4.3 PIPE DATA

4.3.1 Introduction

The Pipe Data is only used when using the Pipe Lay option.

The Pipe Data form is divided into three areas:

1. Data common to all pipes considered in the analysis (top left).
2. Number of pipe types detailed in this data file (top right).
3. Properties specific to each pipe type (lower part).

Pipe Types

Each **Pipe Type** defines a complete pipe assembly. Besides details of the main pipe structure (diameter, wall thickness, material properties), the Pipe Type includes details of coatings and linings applied to the main pipe, plus details of an external piggyback line (including its own coatings and linings if any) and multiple internal lines, all of which contribute to the overall mechanical and structural properties of the line.

Properties can be specified for more than one pipe section, e.g. to allow analysis of a pipe where the wall thickness changes. Specify the number of Pipe Types required and allocate a name to each. Note that the data file may contain definitions of more Pipe Types than are used in the analysis.

Number of Pipe Types

There is no limit on the total number of Pipe Types which may be defined.

Pipe Type Name

Used to identify the Pipe Type elsewhere in the data.

4.3.2 Common

Common pipe data items are as follows:

Code Check

Options are BS8010, DnV 1981, DnV 1996, DnV 2000 (OS-F101), API RP 1111. The implementation of each code is documented in the code check document.

> ***Note:*** *Different pipe codes require different data for their application, so the layout of the Pipe Data form changes as the code check selection changes. Some of these data items appear in the Common Data section, others in the Properties of Pipe Types section.*

Stress Limits

Maximum percent of specified minimum yield stress (SMYS) for controlled and uncontrolled bending (also known as position controlled and load controlled bending respectively). Sections of pipe above the last support (if any present) are treated as supported when the pipe is in sagbend. In all other circumstances the pipe is treated as unsupported. Different levels can be specified for supported and unsupported bending.

Minimum Tension

Minimum allowable tension value for the pipe. This value is used for the acceptance criteria. This acceptance criterion does not apply when the value is set to '~'.

Contents Density

The density of the pipe contents.

Contents State

Two options are available:

- **Fluid**: - Internal pressure increases hydrostatically with depth.
- **Solid**: - Internal pressure is set to zero throughout. The "Solid" option is provided primarily for use when modelling a pipe-in-pipe system in which the annulus between the inner and outer pipes contains a solid (commonly foam) insulating material.

Note: *For a pipe-in-pipe system, this data item defines the density of the contents of the annular space between the carrier pipe and the inner pipe. The contents density for the inner pipe is specified separately.*

Supplementary Requirement U (DnV 2000)

Check this box if Supplementary Requirement U applies - see DnV 2000 pipe code in the code check document for details.

Bending Strain Safety Factor f1 (API RP 1111)

See API RP 1111 pipe code in the code check document for details.

Pipe Construction (DnV 2000 and API RP 1111)

Select appropriate pipe construction process - see the appropriate pipe code in the code check document for details.

Pipe Type

Properties can be specified for more than one pipe section, e.g. to allow analysis of a pipe where the wall thickness changes. Specify the number of Pipe Types required and allocate a name to each.

4.3.3 Main

Outside Diameter

Wall Thickness

Material E

Young's modulus for the pipe material.

Material Yield Stress SMYS

Specified Minimum Yield Stress for the pipe material.

Tensile Strength SMTS (DnV 2000 [OS-F101] and API RP 1111)

Specified Minimum Tensile Strength for the pipe material.

DnV Ovality and API Ovality

Data items used for DnV 1996, DnV 2000 and API RP 1111 code checks. The DnV codes define ovality as $(OD_{max} - OD_{min}) / OD_{mean}$. The API code defines ovality as $(OD_{max} - OD_{min}) / (OD_{max} + OD_{min})$. Therefore the 2 values are related by the equation DnV Ovality = 2 . API Ovality.

Note: *Ovality values are reported as percentages. This means that you should multiply values from the above equations by 100 before inputting them.*

Note: *BS8010 also includes ovality, but the definition is different and the program uses a constant value.*

Poisson Ratio

Material Density

Drag Coefficient

Normal drag coefficient, used for current drag calculation.

4.3.4 Coatings and Linings

Coatings are applied sequentially from the pipe wall outwards. Buoyancy is determined according to the pipe diameter over the outermost coating.

Linings are applied sequentially from the pipe wall inwards. Weight of pipe contents is determined according to pipe diameter inside the innermost lining.

Number of External Coating Layers, Number of Internal Lining Layers

For each coating or lining:

Name

User defined title string.

Thickness, Material Density

4.3.5 Piggyback Line

A single piggyback line may be defined, The line may be either a pipe or an umbilical. The piggyback line contributes to the mass, buoyancy, bend stiffness and hydrodynamic drag of the total pipe structure model. The piggyback line is assumed to carry zero tension.

Piggyback Pipe Data

Outside Diameter

Wall Thickness

Material E

Material Density

Contents Density

Drag Coefficient

Coatings and Linings may be defined as for the main pipe.

Piggyback Umbilical Data

Outside Diameter

Mass Including Contents

EI (Bend Stiffness)

Drag Coefficient

4.3.6 Internal Lines

Arbitrary numbers of internal pipes and umbilicals may be defined. Note that it is the user's responsibility to confirm that the specified internal lines will fit in the space available: the program returns an error if the annular space is less than zero (i.e. the total volume of the specified internal lines exceeds the internal volume of the carrier pipe) but does not carry out a more detailed geometric check.

Internal lines contribute to the mass and bend stiffness of the total pipe structure model but are assumed to carry zero tension.

Internal Pipe Data

Name

User defined title string.

Outside Diameter

Wall Thickness

Material E

Material Density

Contents Density

No provision is made for coatings and linings on internal pipes.

Internal Umbilical Data

Name

User defined title string.

Outside Diameter

Mass Including Contents

EI (Bend Stiffness)

4.4 UMBILICAL DATA

The Umbilical Data is only used when using the Umbilical Lay option.

Name

User defined title string.

Outside Diameter

Mass Including Contents

EA (Axial Stiffness)

EI (Bend Stiffness)

Minimum allowable bend radius, Maximum allowable Tension, Minimum allowable Tension

Used in the acceptance criteria for Complete analyses.

Friction Coefficient

Between umbilical and chute.

Drag Coefficient

Normal drag coefficient, used for current drag calculation.

4.5 INITIATION DATA

4.5.1 Introduction

Initiation Method

Two methods of pipelay initiation are offered:

- In the **Seabed Anchor** system, an anchor is located at a fixed point on the seabed. A constant length wire is connected between the Initiation Head and the anchor, and the ship moves away as pipe is paid out.
- In the **Seabed Sheave** system, a fixed sheave is located on the seabed and a wire is connected from the Initiation Head, through the seabed sheave and back to a winch on the ship. The ship stands off a specified distance horizontally from the sheave and the pipe is paid out under tension from the winch wire. Tension in the wire is adjusted to prevent the pipe becoming over stressed.

Initiation Head

Mass, Volume and Length

The Initiation Head is modelled as a cylinder of the length defined in the data and outside diameter chosen to give the correct volume. The mass is treated as uniformly distributed.

Wire Data (Seabed Anchor Initiation only)

Wire Length

> ***Note:*** *The wire length to be used for the Anchor Initiation analysis is input by the user. A wire length calculation is provided for guidance, but the user is free to accept or adjust this length as he wishes.*

Other wire properties (mass, diameter, etc.) are given in the Common Data.

4.5.2 Payout

Payout Mode

This can be **Automatic** or **User Defined**.

Number of Payout Steps

The number of discrete steps used to model the pipe payout during the Initiation operation.

Length of Pipeline to Payout

- If Payout Mode is set to **Automatic** the total Length to Payout is defined by the user and the table below showing payout length at each step is filled out automatically by the program.
- If Payout Mode is set to **User Defined** the Length of Pipeline to Payout is defined individually for each step. A list of default values is provided, but the user should adjust these to meet the project requirements.

Top Tension for summary

The top tension value used to produce the summary results output. A value of '~' results in the payout step being omitted from the table.

4.5.3 Sheave Initiation

Sheave Efficiency

A measure of the loss in tension round the sheave due to friction. Tension in the haul down wire on the pipe side of the sheave is η times tension on the winch side where η is sheave efficiency.

Vessel Offset

Horizontal distance from the sheave to the vessel origin. An appropriate value may be estimated from the results of the Lay analysis.

> ***Note:*** *These data items only apply when you are using Sheave Initiation.*

4.5.4 Environment

Water Depth

For Seabed Anchor Initiation this is defined at the target point, i.e. the point at which the Initiation Head will touchdown.

For Seabed Sheave Initiation this is defined at the vessel origin.

> ***Note:*** *Water depth at the touchdown point will differ if seabed slope is non-zero.*

Seabed Slope

A positive value means the seabed slopes downwards from touchdown towards the ship.

4.5.5 Current

Current Method and Profile

A current profile can be defined in one of two ways:

- **Power Law**: the current speed at the surface and seabed are specified; current speeds at intermediate depths are defined by a $^{1}/_{7}$ power law.
- **Profile**: the current speed at a series of depths are specified and the program interpolates linearly. The current at the greatest depth specified is applied to any depth below this, for example when a sloping seabed is specified. Similarly, the current at the least depth specified is applied to any depth above this.

Current Direction

Ahead or astern.

4.5.6 Pipe

Model Transition, and Optional Mid-point Load

Check this box if you wish to model initiation of a pipe made up of two sections with different properties (e.g. a change of wall thickness), or with a mid-point load.

Pipe

If no transition is to be modelled, this data item specifies the Pipe Type to be used for the analysis.

Model Transition Data

If a transition is to be modelled, the User specifies:

- The Transition Arclength from Initiation Head - measured positive towards the Lay Vessel.
- The Pipe Type to be used for the upper part of the pipe, adjacent to the Lay Vessel.
- The Pipe Type to be used for the lower part of the pipe, adjacent to the Initiation Head.

Note: *The same pipe type may be used for both upper and lower sections if required. This will usually be the case where a mid-point load is to be modelled.*

4.5.7 Mid-point Load

Model Mid-point Load

Check this box if the analysis is to be carried out including a mid-line load. Note that in order to model a mid-point load, a Transition must be specified in the Pipe data.

Mid-point Load Offset from Transition Point towards Vessel

The offset from the pipe transition to the end of the mid-point load closest to the Initiation Head. A positive value means the mid-point load is closer to the Lay Vessel than the pipe transition.

Mid-point Load details

Mass, Volume and Length of the mid-point load. Mid-point loads are represented as short, stiff sections of Pipe with the appropriate OD (i.e. volume), mass and length.

4.6 LAY DATA

4.6.1 Analysis Cases

Number of Cases to Analyse

The program allows you to select a number of different water depths for analysis.

Water Depth

Defined at the vessel origin.

Note: *Water depth at the touchdown point will differ if the seabed slope is non-zero.*

Seabed Slope

A positive value means the seabed slopes downwards from touchdown towards the ship.

Line Length Calculation

For Lay and Laydown analyses the line (pipe or umbilical) is modelled from the vessel to the seabed. In reality the line would continue some distance along the seabed as far as the anchor. Modelling all of this line would be very time consuming and unnecessary. Instead the program terminates the line once touchdown is reached. We refer to this termination point as the nominal anchor.

These data determine the length of line between the vessel and the nominal anchor. The criteria used to determine the line length is that there should be no uplift at the nominal anchor.

Usually the **Mode** field should be set to **Auto**. For this setting the program uses an iterative method to choose a line length which has no uplift at the nominal anchor for the range of acceptable top tensions.

However, sometime the automatic mode fails. In these cases you should use the **User** setting and input the required line length in the **Value** field. In this case you would typically find a suitable line length by trial and error.

4.6.2 Current

Current Method and Profile

A current profile can be defined in one of two ways:

- **Power Law**: the current speed at the surface and seabed are specified; current speeds at intermediate depths are defined by a $^1/_7$ power law.
- **Profile**: the current speed at a series of depths are specified and the program interpolates linearly. The current at the greatest depth specified is applied to any depth below this, for example when a sloping seabed is specified. Similarly, the current at the least depth specified is applied to any depth above this.

Current Direction

Ahead or astern.

4.6.3 Pipe

Model Transition, and Optional Mid-point Load

Check this box if you wish to model initiation of a pipe made up of two sections with different properties (e.g. a change of wall thickness), or with a mid-point load.

Pipe

If no transition is to be modelled, this data item specifies the Pipe Type to be used for the analysis.

Model Transition Data

If a transition is to be modelled, the User specifies:

- The Transition Arclength from Vessel - measured positive towards the Anchor.
- The Pipe Type to be used for the upper part of the pipe, adjacent to the Lay Vessel.
- The Pipe Type to be used for the lower part of the pipe, adjacent to the Anchor.

Note: *The same pipe type may be used for both upper and lower sections if required. This will usually be the case where a mid-point load is to be modelled.*

Number of Configurations to Analyse and Arclength from Vessel to Pipe Transition

Each environmental case will be repeated for each of the pipe transition arclengths specified.

4.6.4 Mid-point Load

Model Mid-point Load

Check this box if the analysis is to be carried out including a mid-line load. Note that in order to model a mid-point load, a Transition must be specified in the Pipe data.

Mid-point Load Offset from Transition Point towards Anchor

The offset from the end of the mid-point load closest to the Lay Vessel to the pipe transition. A positive value means towards the Anchor.

Mid-point Load details

Mass, Volume and Length of the mid-point load. Mid-point loads are represented as short, stiff sections of Pipe with the appropriate OD (i.e. volume), mass and length.

4.7 LAYDOWN DATA

4.7.1 Laydown Head

Mass, Volume and Length

The Laydown Head is modelled as a cylinder of the length defined in the data and outside diameter chosen to give the correct volume. The mass is treated as uniformly distributed.

4.7.2 Payout

Payout Mode

This can be **Automatic** or **User Defined**.

Number of Payout Steps

The number of discrete steps used to model the wire payout during the Laydown operation.

Length of Pipeline to Payout

- If Payout Mode is set to **Automatic** the total Length to Payout is defined by the user and the table below showing payout length at each step is filled out automatically by the program.
- If Payout Mode is set to **User Defined** the Length of Wire to Payout is defined individually for each step. A list of default values is provided, but the user should adjust these to meet the project requirements.

Top Tension for summary

The top tension value used to produce the summary results output. A value of '~' results in the payout step being omitted from the table.

4.7.3 Environment

Water Depth

This is defined at the target point, i.e. the point at which the Laydown Head will touchdown.

> ***Note:*** *Water depth at the touchdown point will differ if the seabed slope is non-zero.*

Seabed Slope

A positive value means the seabed slopes downwards from touchdown towards the ship.

4.7.4 Line Length

Line Length Calculation

These data items are used in the same way as the equivalent Lay Data items.

4.7.5 Current

Current Method and Profile

A current profile can be defined in one of two ways:

- **Power Law**: the current speed at the surface and seabed are specified; current speeds at intermediate depths are defined by a $^{1}/_{7}$ power law.
- **Profile**: the current speed at a series of depths are specified and the program interpolates linearly. The current at the greatest depth specified is applied to any depth below this, for example when a sloping seabed is specified. Similarly, the current at the least depth specified is applied to any depth above this.

Current Direction

Ahead or astern.

4.7.6 Pipe

Model Transition, and Optional Mid-point Load

Check this box if you wish to model initiation of a pipe made up of two sections with different properties (e.g. a change of wall thickness), or with a mid-point load.

Pipe

If no transition is to be modelled, this data item specifies the Pipe Type to be used for the analysis.

Model Transition Data

If a transition is to be modelled, the User specifies:

- The Transition Arclength from Laydown Head - measured positive towards the Anchor.
- The Pipe Type to be used for the upper part of the pipe, adjacent to the Laydown Head.
- The Pipe Type to be used for the lower part of the pipe, adjacent to the Anchor.

Note: *The same pipe type may be used for both upper and lower sections if required. This will usually be the case where a mid-point load is to be modelled.*

Number of Configurations to Analyse and Arclength from Vessel to Pipe Transition

Each environmental case will be repeated for each of the pipe transition arclengths specified.

4.7.7 Mid-point Load

Model Mid-point Load

Check this box if the analysis is to be carried out including a mid-line load. Note that in order to model a mid-point load, a Transition must be specified in the Pipe data.

Mid-point Load Offset from Transition Point towards Anchor

The offset from the end of the mid-point load closest to the Lay Vessel to the pipe transition. A positive value means towards the Anchor.

Mid-point Load details

Mass, Volume and Length of the mid-point load. Mid-point loads are represented as short, stiff sections of Pipe with the appropriate OD (i.e. volume), mass and length.

5 ANALYSIS

5.1 ANALYSIS METHODS

5.1.1 Calculation Modes

For Initiation, Lay and Laydown the program offers two basic calculation modes:

Complete Analysis

The object of this analysis is to determine the range of values of top tension within which the operation can proceed. This is assessed with reference to selected pipe lay code and to a number of other acceptance criteria.

The analysis determines the maximum permissible tension case by increasing the pipe/umbilical span from ship to touchdown until one or more of the acceptance criteria is infringed. The minimum tension case is determined similarly by reducing the span until one or more of the acceptance criteria is again infringed. This defines the working range. The software then analyses and reports results for a range of intermediate cases. Which intermediate cases are analysed is determined by the Analysis Data.

Single Case Analysis

This mode gives access to more detailed results for a specific analysis case specified by the top tension.

5.1.2 Acceptance Criteria

Pipelines

The following acceptance criteria are applied when using the Pipe Lay option:

- No local buckling as defined by the selected design code.
- Stresses not to exceed levels set by the user. These levels are specified as percentages of Yield Stress (SMYS). A distinction is made between regions of supported and unsupported bending. Sections of pipe above the last support (if any present) are treated as supported when the pipe is in sagbend. In all other circumstances the pipe is treated as unsupported. Different levels can be specified for supported and unsupported bending (also known as position controlled and load controlled bending respectively).
- Top tension not to exceed Maximum top tension (Initiation and Lay only).
- Top tension not to exceed Handling winch capacity (Laydown only).
- Horizontal component of force applied to vessel not to exceed vessel bollard pull.
- Pipe not to contact any constraints.
- Tension in pipe not to infringe Minimum tension. Note that this criterion does not apply when Minimum tension is '~'.

Umbilicals

The following acceptance criteria are applied when using the Umbilical Lay option:

- Minimum allowable bend radius specified in the data not to be infringed.
- Tension not to infringe Maximum allowable Tension.
- Tension in umbilical not to infringe Minimum allowable Tension. Note that this criterion does not apply when Minimum tension is '~'.
- Umbilical must not wrap beyond the end of the chute as determined by the Chute Included Angle.

5.2 LAY ANALYSIS

5.2.1 Complete Lay Analysis

Calculation Procedure

The automatic calculation procedure is as follows:

1. For the first selected water depth, determine the pipe/umbilical length required for analysis: the length is selected such that there is always a length of pipe/umbilical on the seabed for any load case which meets the acceptance criteria.
2. Set up the system model.
3. The ship is treated as fixed at X = 0 with the pipe in the X-Z plane. The seabed end of the pipe/umbilical will be positioned at X < 0.
4. Adjust the X position of the seabed end of the pipe/umbilical to identify the maximum span consistent with the acceptance criteria.
5. Adjust the X position of the seabed end of the pipe/umbilical to identify the minimum span consistent with the acceptance criteria.
6. Where pipe supports are defined: Adjust the X position of the seabed end of the pipe/umbilical to identify points where successive supports leave contact with the pipe. Analyse for additional X positions of the seabed end of the pipe to give 3 load cases in each interval between maximum pipe span and contact with support #1, between support #1 contact and support #2 contact, and so on.
7. Where no pipe supports are defined: Analyse for 20 additional X positions at equal increments of top tension between maximum and minimum spans.
8. Where a transition or mid-point load is specified, repeat the analysis for each case specified.
9. Repeat for other water depths as specified.

Results

The Common Data and a number of derived parameters are collected in the Common Results sheet, available following successful completion of any analysis.

In addition to the common results, one results worksheet is produced for each water depth and transition/mid-point load position. Each sheet gives the input data and computed results specific to that water depth. The data items are self-explanatory. Results items are given for Pipelines and Umbilicals.

Note that in each case, a table of results is presented running from the lowest to the highest top tension compatible with the specified acceptance criteria.

Pipeline Results

The Pipeline results output for Complete Lay Analysis is presented as a summary of the load case details followed by a table of results from the lowest to the highest top tension compatible with the specified constraints. The tabulated results items are as follows:

Vessel Offset

The horizontal distance between the pipe top end and the nominal anchor.

Support Reactions

Reaction force at each pipe support.

Support Clearance

Distance of pipe underside to the pipe support specified as a reference offset.

Pipe Lift

Distance of pipe underside from datum at the Pipe Sensor Position defined in the data. Positive values of pipe lift mean that the pipe is above or aft of the datum.

- If the sensor rotates with the ramp then pipe lift is measured normal to the ramp, from the sensor to the pipe underside.
- If the sensor does not rotate with the ramp then pipe lift is measured horizontally, from the sensor to the pipe underside.

Tension; Top and Bottom

Tension in the pipe at the Pipe Top End and at touchdown respectively.

Top Bend Moment

The bend moment at the Pipe Top End.

Suspended Length

Length of pipe from Suspended Length Origin to touchdown point.

Horizontal Projection

Horizontal distance from Suspended Length Origin to touchdown point.

Projection Growth

Suspended length minus horizontal projection.

Maximum Stresses in Overbend and Sagbend

The equivalent stress, also known as von Mises stress.

The pipe is in **overbend** if the pipe's declination from vertical increases as you move down the pipe. The pipe is in **sagbend** when it is not in overbend, ie. if the pipe's declination from vertical decreases as you move down the pipe.

> ***Note:*** *The value reported is the maximum value between the top end and the touchdown point.*

Departure Angle

The pipe angle to the horizontal at sea level.

Constraint Clearance

Minimum clearance between pipe outer surface and any constraint. A negative value means that the constraint has been infringed.

Umbilical Results

The Umbilical results output for Complete Lay Analysis is presented as a summary of the load case details followed by a table of results from the lowest to the highest top tension compatible with the specified constraints. The tabulated results items are as follows:

Vessel Offset

The horizontal distance between the umbilical top end and the nominal anchor.

Maximum Tension

Tension in the umbilical at liftoff. Liftoff is the point at which the umbilical lifts off the chute.

Top Tension

Tension at the top of the chute. The difference between this and maximum tension is due to chute friction.

Bottom Tension

Tension in the umbilical at touchdown.

Minimum Bend Radius

The minimum bend radius of the umbilical between liftoff and touchdown.

Liftoff Angle

The declination from the horizontal at liftoff.

Suspended Length

Length of umbilical from liftoff to touchdown point.

Horizontal Projection

Horizontal distance from liftoff to touchdown point.

Projection Growth

Suspended length minus horizontal projection.

5.2.2 Single Case Lay Analysis

Additional Data

Environment, Line Length, Current, Pipe and Mid-point load

These data can be different from that used in the Complete Lay Analysis.

Required Top Tension

The Single Analysis will report results for the entire line corresponding to this value of top tension.

Top End Condition

If the Distance to Upper Pipe Hangoff is zero then this data item is not required and the top end condition is built-in at the Pipe Top End.

Otherwise, the Top End Condition can be **Built in at Pipe Top End** or **Pinned at Upper Hangoff -** defines the top end condition for the analysis as a built in condition at the Pipe Top End or a pinned condition at the Upper Pipe Hangoff respectively. The Pinned at Upper Hangoff condition would be used when analysing a 'J' lay operation.

Write OrcaFlex File

If this is checked then an OrcaFlex data file is saved after the analysis is complete.

Pipeline Results

The Pipeline results output for Single Case Lay Analysis is presented as a summary of the load case details followed by detailed results for each point along the line.

Load Case Summary

Support Reactions, or Clearance Between Pipe and Support where reaction is zero

Constraint Clearances

Minimum clearance between pipe outer surface and each constraint. A negative value means that the constraint has been infringed.

Pipe Length

Total length of pipe considered in the analysis.

Suspended Length.

Length of pipe from Suspended Length Origin to touchdown point.

Mid-Point Load Data (where applicable)

Detailed Results

Arclength

Length along the pipe measured from the Pipe Top End.

Segment Type

Pipe or MPL (mid point load).

Position X, Z

Coordinates in the vessel axes of locations on the pipe for which results are reported.

Angle to Horizontal

Tension, Shear, Curvature, Bend Moment

Forces and moments at the location in question.

Carrier Pipe Shear and Bend Moment

These are only presented when a piggyback line or internal lines are analysed. These loads exclude the shear and bend moment loads in the piggyback line and internal lines.

Stress Components, Equivalent Stress, % Allowable, Code Check Results

Calculated according to the specified design code. The implementation of each code is documented in the code check document.

Umbilical Results

The Umbilical results output for Single Case Lay Analysis is presented as a summary of the load case details followed by detailed results.

Load Case Summary

Umbilical Length

Total length of umbilical considered in the analysis.

Suspended Length

Length of umbilical from lift-off to touchdown point.

Umbilical Liftoff Angle

Angle below horizontal to the point at which the umbilical leaves contact with the chute.

Top Tension

Detailed Results

Arclength

Length along the pipe measured from lift-off.

Segment Type

Position X, Z

Coordinates in the vessel axes of locations on the umbilical for which results are reported.

Angle to Horizontal

Tension, Shear, Curvature, Bend Moment and Bend Radius

Values at the location in question.

5.3 INITIATION ANALYSIS

5.3.1 Introduction

As well as Complete and Single Case analyses two additional analyses are offered for Seabed Anchor Initiation only:

- Calculate wire length: determines the minimum wire length required to avoid uplift at the Anchor during initiation.
- Anchor proof test: determines the minimum wire length required to avoid uplift at the Anchor during proof test.

5.3.2 Complete Initiation Analysis

Calculation Procedure

The analysis is carried out for a series of steps corresponding to increasing lengths of pipe paid out. The first step has the Initiation Head at the Initiation Payout Origin specified in the Vessel data, and pipe length is increased at each subsequent step as defined in the input data. The number of steps and corresponding pipe lengths can be set manually by the user, or the program will set them automatically.

Payout Mode: Automatic

The user sets the number of steps to be analysed and the total length of pipe to be paid out. The length of pipe paid out at successive steps is determined automatically by the program.

The total length of pipe to be paid out should normally be such that, for the last step of the calculation, the Initiation Head lies horizontal on the seabed. An appropriate length can be estimated from the results of a lay analysis.

Payout Mode: User Defined

The user defines the number of steps to be analysed and the length of pipe paid out at each step.

Calculation Procedure

For each step in the initiation procedure, the analysis is then similar to that for Complete Lay analysis. Note that:

- For Anchor Initiation analysis, the Anchor is treated as fixed and the X position of the ship is adjusted
- For Sheave Initiation analysis, both Anchor (i.e. the seabed sheave) and the ship are fixed and the pull-down wire length is adjusted.

Note: *When the pipe length overhanging the rollers is short, reducing tension may not cause overstress in the pipe so there may be no minimum tension case. To avoid computing difficulties, the analysis stops when the horizontal component of tension falls to a value of 10kN.*

When the analysis is complete, the user selects the condition preferred at each step and these preferred cases are reported in a summary table. The summary table is obtained by selecting the Calculation **|** Initiation Summary menu.

Results

The Common Data and a number of derived parameters are collected in the Common Results sheet, available following successful completion of any analysis.

In addition to the common results, one results worksheet is produced for each step in the initiation sequence. Results are output for maximum and minimum tension cases and all intermediate cases in a form similar to the pipelay results.

Complete Initiation analysis results items for Pipelines and Umbilicals are reported.

Results Summary

This option builds a table of results containing one entry for each payout step of the initiation analysis. These entries are specified in terms of a top tension value. The top tension can be specified either on the Initiation data form or on the complete initiation results worksheet for the corresponding payout step. A value of '~' results in the payout step being omitted from the table.

The summary table is obtained by selecting the Calculation **|** Initiation Summary menu.

Pipeline Results

The Pipeline results output for Complete Initiation Analysis is presented as a summary of the load case details followed by a table of results from the lowest to the highest top tension compatible with the specified constraints. The tabulated results items are as follows:

Support Reactions

Reaction force at each pipe support.

Support Clearance

Distance of pipe underside to the pipe support specified as a reference offset.

Pipe Lift

Distance of pipe from datum at the Pipe Sensor Position defined in the data. Positive values of pipe lift mean that the pipe is above or aft of the datum.

- If the sensor rotates with the ramp then pipe lift is measured normal to the ramp, from the sensor to the pipe underside.
- If the sensor does not rotate with the ramp then pipe lift is measured horizontally, from the sensor to the pipe underside.

Distance to Target (Seabed Sheave Initiation)

Horizontal distance from Suspended Length Origin to Target. The Target is defined as the place on the seabed where the Initiation head will land.

Wire Length (Seabed Sheave Initiation)

From the Initiation Head to the Anchor and back to the Handling Sheave.

Initiation Head Angle

To horizontal.

Anchor Uplift (Seabed Anchor Initiation)

Wire angle to seabed.

Sheave Results (Seabed Sheave Initiation)

Vertical, horizontal and total (resultant) force applied to the sheave by the wire (both catenaries), and the direction of the resultant (angle to horizontal).

Top Tension

Pipe tension at the Pipe Top End.

Anchor Tension (Seabed Anchor Initiation)

Wire tension at the Anchor.

Return Tension (Seabed Sheave Initiation)

Wire tension at the Handling Sheave.

Top Bend Moment

The bend moment at the Pipe Top End.

Pipe and Wire Combined Suspended Length

Length from Suspended Length Origin to touchdown point.

Pipe and Wire Combined Horizontal Projection

Horizontal distance from Suspended Length Origin to touchdown point.

Pipe and Wire Combined Projection Growth

Pipe and Wire Combined Suspended Length minus Pipe and Wire Combined Horizontal Projection.

Pipe Suspended Length

Length of pipe from Suspended Length Origin to Initiation Head.

Pipe Horizontal Projection

Horizontal distance from Suspended Length Origin to Initiation Head.

Pipe Vertical Projection

Vertical distance from Suspended Length Origin to Initiation Head.

Wire Suspended Length

Length of wire from Initiation Head to touchdown point.

Wire Horizontal Projection

Horizontal distance from Initiation Head to touchdown point.

Wire Vertical Projection

Vertical distance from Initiation Head to touchdown point.

Maximum Stress

The equivalent stress, also known as von Mises stress.

Departure Angle

Pipe angle to the horizontal at sea level.

Constraint Clearance

Minimum clearance between pipe outer surface and any constraint. A negative value means that the constraint has been infringed.

Umbilical Results

The Umbilical results output for Complete Initiation Analysis is presented as a summary of the load case details followed by a table of results from the lowest to the highest top tension compatible with the specified constraints. The tabulated results items are as follows:

Distance to Target

Horizontal distance from liftoff to target. Liftoff is the point at which the umbilical lifts off the chute.

Maximum Tension

Tension in the umbilical at liftoff.

Top Tension

Tension at the top of the chute. The difference between this and maximum tension is due to chute friction.

Bottom Tension

Tension in the umbilical at touchdown.

Minimum Bend Radius

The minimum bend radius of the umbilical between liftoff and touchdown.

Liftoff Angle

The declination from the horizontal at liftoff.

Umbilical Suspended Length

Length of umbilical from Suspended Length Origin to Initiation Head.

Umbilical Horizontal Projection

Horizontal distance from Suspended Length Origin to Initiation Head.

Umbilical Vertical Projection

Vertical distance from Suspended Length Origin to Initiation Head.

Wire Suspended Length

Length of wire from Initiation Head to touchdown point.

Wire Horizontal Projection

Horizontal distance from Initiation Head to touchdown point.

Wire Vertical Projection

Vertical distance from Initiation Head to touchdown point.

5.3.3 Single Case Initiation Analysis

Additional Data

Pipe and Mid-point load

These data can be different from that used in the Complete Initiation Analysis.

Required Top Tension

The Single Analysis will report results for the entire line corresponding to this value of top tension.

Pipe or Umbilical length

The length of pipe required for the analysis. This is measured from the Initiation Payout Origin to the Initiation Head. This value corresponds to the Payout value of the Complete Analysis.

Top End Condition

If the Distance to Upper Pipe Hangoff is zero then this data item is not required and the top end condition is built-in at the Pipe Top End.

Otherwise, the Top End Condition can be **Built in at Pipe Top End** or **Pinned at Upper Hangoff -** defines the top end condition for the analysis as a built in condition at the Pipe Top End or a pinned condition at the Upper Pipe Hangoff respectively. The Pinned at Upper Hangoff condition would be used when analysing a 'J' lay operation.

Write OrcaFlex File

If this is checked then an OrcaFlex data file is saved after the analysis is complete.

Pipeline Results

The Pipeline results output for Single Case Initiation Analysis is presented as a summary of the load case details followed by detailed results.

Load Case Summary

Support Reactions, or Clearance Between Pipe and Support where reaction is zero

Constraint Clearances

Minimum clearance between pipe outer surface and each constraint. A negative value means that the constraint has been infringed.

Pipe Length

The length of pipe used in the analysis, measured from the Initiation Payout Origin to the Initiation Head.

Wire Length (Seabed Anchor Initiation)

Anchor Uplift (Seabed Anchor Initiation)

Wire angle to horizontal at the anchor.

Total Wire Length including return wire (Seabed Sheave Initiation)

Return Line Top Tension (Seabed Sheave Initiation)

Sheave Results: Vertical Force, Horizontal Force, Resultant Force, Resultant Angle (Seabed Sheave Initiation)

Mid-point Load and Initiation Head details (Seabed Sheave Initiation)

Detailed Results

Arclength

Length along the pipe measured from the Pipe Top End.

Segment Type

Pipe, Initiation Head or wire.

Position X, Z

Coordinates in the vessel axes of locations on the pipe for which results are reported.

Angle to Horizontal

Tension, Shear, Curvature, Bend Moment

Forces and moments at the location in question.

Carrier Pipe Shear and Bend Moment

These are only presented when a piggyback line or internal lines are analysed. These loads exclude the shear and bend moment loads in the piggyback line and internal lines.

Stress Components, Equivalent Stress, % Allowable, Code Check Results

Calculated according to the specified design code. The implementation of each code is documented in the code check document.

Sheave Initiation Return Line

For Sheave Initiation, this is followed by a further table giving the geometry of and tension in the return wire.

Umbilical Results

The Umbilical results output for Single Case Initiation Analysis is presented as a summary of the load case details followed by detailed results.

Load Case Summary

Umbilical Length

Total length of umbilical considered in the analysis.

Wire Length

Total length of wire considered in the analysis.

Anchor Uplift

Uplift angle at Anchor.

Umbilical Liftoff Angle

The declination from the horizontal at liftoff.

Top Tension

Tension at the top of the chute. The difference between this and maximum tension is due to chute friction.

Detailed Results

Arclength

Length along the pipe measured from liftoff.

Segment Type

Umbilical, Initiation Head or wire.

Position X, Z

Coordinates in the vessel axes of locations on the umbilical for which results are reported.

Angle to Horizontal

Tension, Shear, Curvature, Bend Moment and Bend Radius

Values at the location in question.

5.3.4 Wire Length Calculation

The pipe is assumed to be fully prepared for lay initiation, with the flange connecting the pipe to the Initiation Head at the Initiation Payout Origin, and the initiation wire connected. A calculation is then carried out to determine the wire length to the anchor point such that when the Initiation Head is parallel to the ramp, the wire touches down just in front of the Anchor so that the Anchor does not experience uplift. Wire length is reported.

Note: *This wire length is not automatically passed to the initiation analysis modules as the user may wish to adjust the wire length for practical reasons.*

5.3.5 Anchor Proof Test

The Anchor is proof tested to a specified load before installation commences. The wire length for the proof test is chosen such that there will be no uplift on the Anchor during the test.

In addition to the Initiation Data, one more data item is requested:

Required Bottom Tension

Typically 1.5 times the maximum anchor load determined in an installation analysis.

The wire length and ship position are adjusted such that when the tension at the seabed is as specified there is just no uplift on the Anchor.

The wire length required to ensure zero uplift at the anchor, and the corresponding top tension in the wire are reported.

5.4 LAYDOWN ANALYSIS

5.4.1 Introduction

For laydown, a wire is connected from the Handling Sheave on the ship to the pipe end cap. The ship moves forward paying out the wire until the whole of the pipe lies on the seabed. Analysis is carried out for a series of steps corresponding to increasing lengths of wire paid out.

At the start of the operation, the pipe is clamped at a point near the end of the ramp while the pipe is cut and the Laydown Head welded in place. The laydown wire is then connected to the Laydown Head and tensioned. The clamp is then released and the laydown operation proceeds.

For modelling purposes, the pipe is represented up to an arbitrary anchor point on the seabed, beyond the point at which the pipe will lift under maximum tension.

5.4.2 Complete Laydown Analysis

Calculation Procedure

The laydown analysis is carried out for a series of steps corresponding to increasing lengths of wire paid out. The first step has the Laydown Head at the Laydown Payout Origin. Wire length is payed out at each subsequent step as defined in the input data.

The total length of wire to be paid out should normally be such that for the last step of the calculation the Laydown Head lies horizontally on the seabed. The wire length corresponding to this condition depends on the tension in the wire, and the user is asked to specify the maximum wire length to be considered in the analysis. An appropriate length can be estimated by re-running the Anchor Proof Test calculation for the maximum value of wire tension expected at the seabed.

Having determined the wire lengths corresponding to the first and last steps, we now have to decide how many intermediate steps should be analysed, and what wire lengths to use for each one. The number of steps and corresponding wire lengths can be set manually by the user, or the program will set them automatically.

For each step in the laydown procedure, the analysis is then similar to that for Complete Lay Analysis, with the top tension limited by the Handling Winch Capacity rather than the Maximum Top Tension.

When the analysis is complete, the user selects the condition preferred at each step and these preferred cases are reported in a summary table. The summary table is obtained by selecting the Calculation | Laydown Summary menu.

Results

The Common Data and a number of derived parameters are collected in the Common Results sheet, available following successful completion of any analysis.

In addition to the common results, one results worksheet is produced for each step in the initiation sequence. Results are output for maximum and minimum tension cases and all intermediate cases in a form similar to the pipelay results.

Complete Laydown analysis results items for Pipelines and Umbilicals are reported.

One results worksheet is produced for each step in the laydown sequence. Results are output for maximum and minimum tension cases and all intermediate cases in a form similar to the pipelay results. The data items are self-explanatory. Results items are reported for Pipelines and Umbilicals.

Results Summary

This option builds a table of results containing one entry for each payout step of the laydown analysis. These entries are specified in terms of a top tension value. The top tension can be specified either on the Laydown data form or on the complete laydown results worksheet for the corresponding payout step. A value of '~' results in the payout step being omitted from the table.

The summary table is obtained by selecting the Calculation | Laydown Summary menu. A second summary table is also created to represent Recovery.

Pipeline Results

The Pipeline results output for Complete Laydown Analysis is presented as a summary of the load case details followed by a table of results from the lowest to the highest top tension compatible with the specified constraints. The tabulated results items are as follows:

Distance to Target

Horizontal distance from Suspended Length Origin to Target. The Target is defined as the place on the seabed where the Laydown head will land.

Laydown Head Angle

To horizontal.

Tension, Top and Bottom

Wire tension at the Handling Sheave, and pipe tension at touchdown respectively.

Pipe and Wire Combined Suspended Length

Length from Handling Sheave to touchdown point.

Pipe and Wire Combined Horizontal Projection

Horizontal distance from Handling Sheave to touchdown point.

Pipe and Wire Combined Projection Growth

Pipe and Wire Combined Suspended Length minus Pipe and Wire Combined Horizontal Projection.

Pipe Suspended Length

Pipe length from touchdown to Laydown Head.

Pipe Horizontal Projection

Horizontal distance from touchdown to Laydown Head.

Pipe Vertical Projection

Vertical distance from touchdown to Laydown Head.

Wire Suspended Length

Wire length from Laydown Head to Handling Sheave.

Wire Horizontal Projection

Horizontal distance from Laydown Head to Handling Sheave.

Wire Vertical Projection

Vertical distance from Laydown Head to Handling Sheave.

Constraint Clearance

Minimum clearance between pipe outer surface and any constraint. A negative value means that the constraint has been infringed.

Maximum Stress

The equivalent stress, also known as von Mises stress.

Umbilical Results

The Umbilical results output for Complete Laydown Analysis is presented as a summary of the load case details followed by a table of results from the lowest to the highest top tension compatible with the specified constraints. The tabulated results items are as follows:

Distance to Target

Horizontal distance from liftoff to target.

Top Tension

Tension at the top of the chute.

Bottom Tension

Tension in the umbilical at touchdown.

Minimum Bend Radius

The minimum bend radius of the umbilical between liftoff and touchdown.

Liftoff Angle

The declination from the horizontal at liftoff.

Umbilical Suspended Length

Umbilical length from touchdown to Laydown Head.

Umbilical Horizontal Projection

Horizontal distance from touchdown to Laydown Head.

Umbilical Vertical Projection

Vertical distance from touchdown to Laydown Head.

Wire Suspended Length

Wire length from Laydown Head to Suspended Length Origin.

Wire Horizontal Projection

Horizontal distance from Laydown Head to Suspended Length Origin.

Wire Vertical Projection

Vertical distance from Laydown Head to Suspended Length Origin.

5.4.3 Single Case Laydown Analysis

Additional Data

Pipe and Mid-point load

These data can be different from that used in the Complete Laydown Analysis.

Required Top Tension

The Single Analysis will report results for the entire line corresponding to this value of top tension.

Wire Payout

The length of wire required for the analysis. This is measured from the Laydown Payout Origin to the Laydown Head. This value corresponds to the Payout value of the Complete Analysis.

Write OrcaFlex File

If this is checked then an OrcaFlex data file is saved after the analysis is complete.

Pipeline Results

The Pipeline results output for Single Case Laydown Analysis is presented as a summary of the load case details followed by detailed results.

Load Case Summary

Support Reactions, or Clearance Between Pipe and Support where reaction is zero

Constraint Clearances

Minimum clearance between pipe outer surface and each constraint. A negative value means that the constraint has been infringed.

Wire Length, Pipe Length

Mid-point Load and Initiation Head details

Detailed Results

Arclength

Length along the pipe measured from the Pipe Top End.

Segment Type

Pipe, Laydown Head or wire.

Position X, Z

Coordinates in the vessel axes of locations on the pipe for which results are reported.

Angle to Horizontal

Tension, Shear, Curvature, Bend Moment

Forces and moments at the location in question.

Carrier Pipe Shear and Bend Moment

These are only presented when a piggyback line or internal lines are analysed. These loads exclude the shear and bend moment loads in the piggyback line and internal lines.

Stress Components, Equivalent Stress, % Allowable, Code Check Results

Calculated according to the specified design code. The implementation of each code is documented in the code check document.

Umbilical Results

The Umbilical results output for Single Case Laydown Analysis is presented as a summary of the load case details followed by detailed results.

Load Case Summary

Wire Length, Umbilical Length

Mid-point Load and Initiation Head details

Detailed Results

Arclength

Length along the pipe measured from liftoff.

Segment Type

Umbilical, Laydown Head or wire.

Position X, Z

Coordinates in the vessel axes of locations on the umbilical for which results are reported.

Angle to Horizontal

Tension, Shear, Curvature, Bend Moment and Bend Radius

Values at the location in question.

5.4.4 Abandonment and Recovery Analysis

Abandonment analysis is the same as Laydown analysis but may have different properties for the pipe end cap and wire, and may take place at a location where the water depth differs from that at the planned termination point. Abandonment analysis is carried out in OrcaLay by re-running the Laydown analysis with data amended as necessary.

Recovery is the reverse of abandonment and the same quasi-static analysis applies. For convenience, after each Laydown analysis, OrcaLay provides a Recovery Output table showing the same results as for Laydown/Abandonment but with the steps in reverse order.